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(71) Applicants  
**Blohm & Voss AG,**  
**(FR Germany),**  
**Hermann-Blohm-Str 3**  
**2000 Hamburg 11**  
**Federal Republic of**  
**Germany**  
(72) Inventor  
**Claus Wagner**  
(74) Agents  
**James G Morgan,**  
**77 Malmesbury Road,**  
**Chippenham,**  
**Wiltshire SN15 1PU**

(54) **Flettner rotors for ship propulsion**

(57) A wind drive for a ship comprises a Flettner-rotor 1 and an sail 3 which is symmetrical and rotatable about its pitch axis 4. In operation the Flettner-rotor 1 is rotated about its axis 2 and this gives rise to a high flow velocity and a low pressure region where the surface of the rotor is moving with the wind, and a low flow velocity and a high pressure region where the surface of the rotor is moving against the wind. The high and low pressure areas cooperate to generate a propulsive thrust. The sail, which can be a rigid sail 3 or a cloth sail is positioned so that it does not affect the flow processes at the rotor but still profits from the higher flow velocities. The sail thus also generates a propulsive thrust.

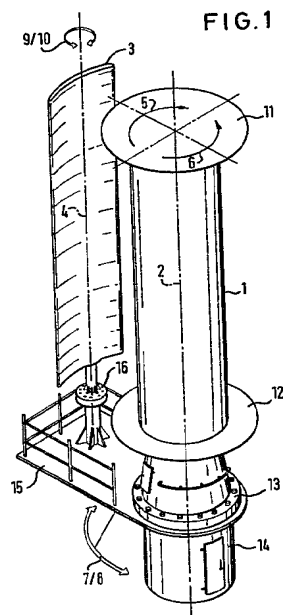


FIG. 1

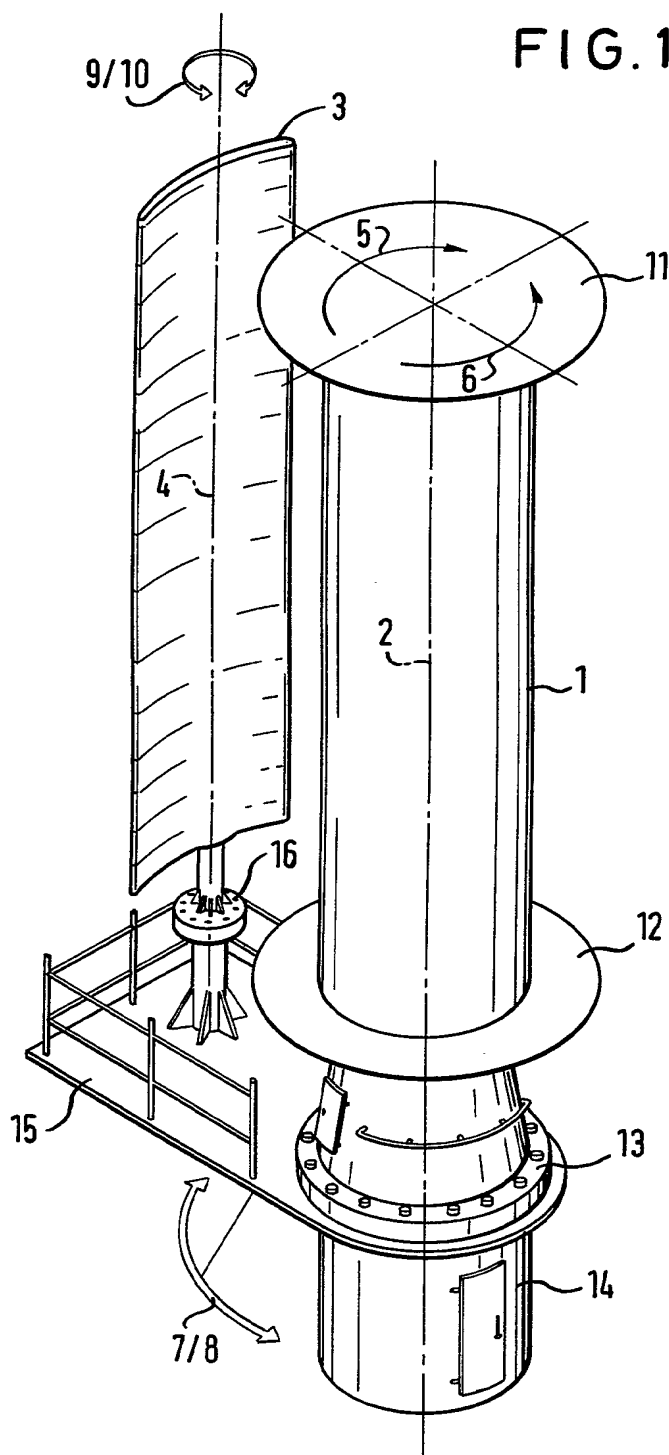


FIG. 2

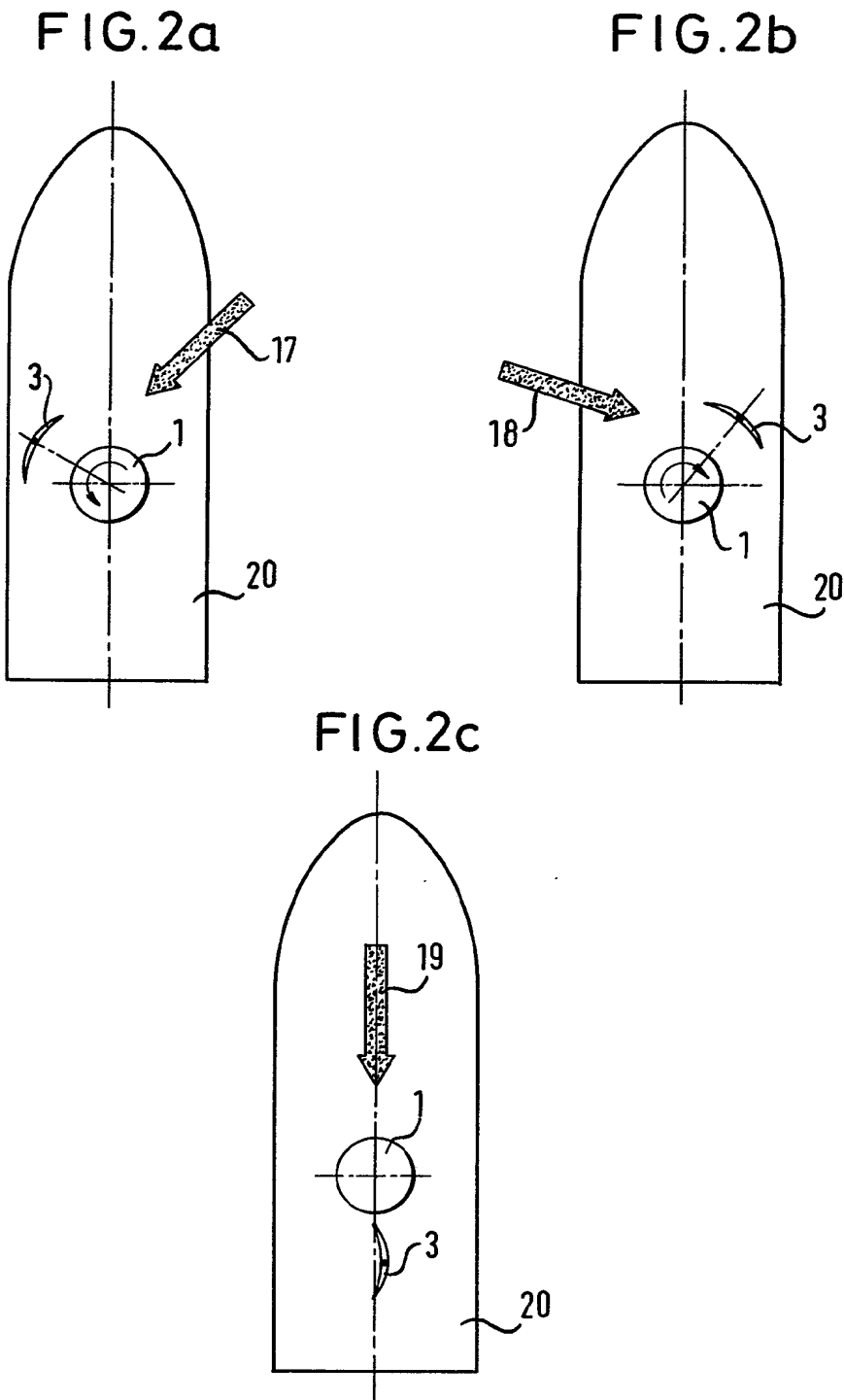
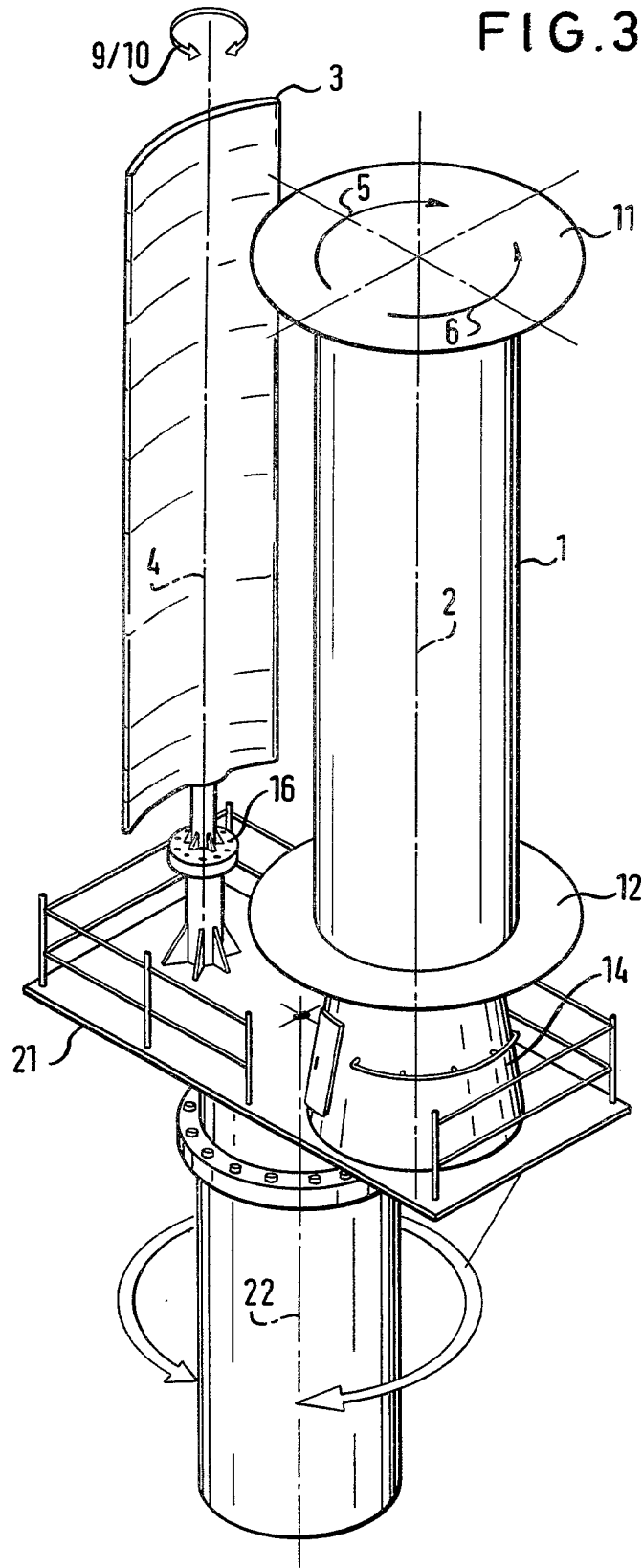
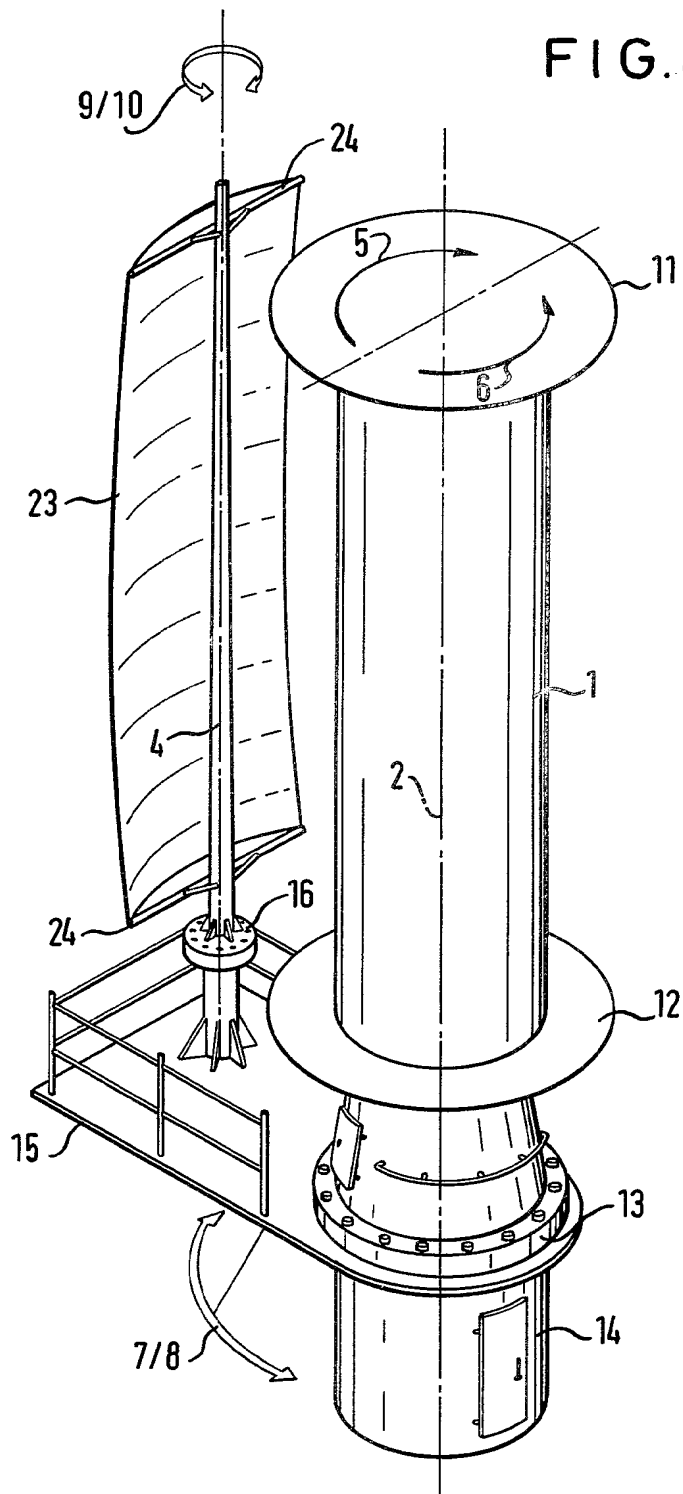


FIG. 3



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FIG. 4



## SPECIFICATION

### Wind drive for ships

5 The invention relates to a wind drive for ships comprising a Flettner-rotor and a surface which is influenced by the flow conditions at the periphery of the rotor, is swivellable about the rotor axis and is rotatable about a pitch axis of its own.

10 In drives of the above described kind the surface has approximately the form of a rudder in order to bring about a control effect and in order to improve the working efficiency of the rotor.

Apart from ships drives in which a rotating cylinder with end discs develops a propulsive force when acted on by the wind (Flettner-rotor) it is also known to use sails (principle of the Rah-sail) for ships propulsion.

15 The problem underlying the invention is to provide a wind drive, or auxiliary wind drive, for ships which has better efficiency than the known wind exploiting devices. This means that the performance of the wind drive in accordance with the invention should be significantly better, related to its constructional size, than that of the known devices consisting of sail or rotor.

20 Starting from the initially described known wind drive this problem is solved by an arrangement in which the surface is formed by a sail which is symmetrical about its pitch axis and rotatable through 360° about the pitch axis, with the sail also being acted on, in part, by the undisturbed wind flow.

25 The technical flow processes occurring at a cylinder against which the wind blows are exploited in this way for propulsion or thrust generation by an accurately spaced and pitched symmetrical sail.

30 Further developments of the invention are to be found in the subclaims. Of these developments the jointly swivellable rotor and sail (see Fig. 3) serve to facilitate more rapid and better matching of changes in the wind direction to the desired course of the ship.

35 The thrust or propulsion generated by a rotating cylinder against which the wind blows arises, in accordance with the "Magnus-effect", in known manner from the circulatory flow (at the surface of the cylinder jacket) and the parallel air flow (wind) superimposed thereon. This results in a large flow velocity and an area of low pressure on that side of the cylinder where the direction of rotation of the cylinder and the wind direction are the same.

40 A smaller flow velocity and an area of excess pressure arises at the opposite side of the cylinder where the cylindrical jacket runs counter to the wind flow. If now a symmetrical sail is arranged in the low pressure area of the rotor so that, on the one hand, it does not negatively influence the flow processes at the rotor but, on the other hand, just profits from the higher flow velocities, then advantageous flow conditions exist for the sail. The total thrust of the wind drive of the invention results from the joint propulsive effects, i.e. thrust from the rotor and from the

sail.

45 The dimensions of the rotor and the sail surface have a specific ratio one to the other. It is assumed that the rotor diameter and the rotor length are proportioned approximately in the ratio 1:4. The sail area is so dimensioned that it exactly matches the height between the two end discs of the rotor. The width of the sail surface should correspond approximately to the diameter of the rotor, can however also be broader or narrower. In order to avoid influencing the flow processes at the rotor the space between the sail surface and the rotor jacket should not be less than 0.7  $D_r$  ( $D_r$  = rotor diameter). In operation the sail is first set parallel to the surface of the rotor jacket, i.e. the wind inlet edge and the wind outlet edge of the sail surface are set at the same distance from the axis of rotation of the rotor. In order to achieve the most favourable pitch angle the sail is made rotatable. This rotational movement is achieved by arranging a rotational joint and a hydraulic remotely actuated turning motor in the support mast for the sail surface. In order to exploit winds from different directions relative to the ship's course using the wind drive of the invention the rotor carrier is fixedly arranged on the ship's deck while the sail can be guided around the longitudinal axis of the rotor.

50 For this purpose a foundation plate on which the support mast for the sail surface is mounted is arranged on the rotor carrier by means of a rotational joint.

55 An electrical or hydraulically actuated positioning device, which is automatically controlled by a wind direction measuring system, turns the foundation plate with the sail to the correct pitch angle appropriate to the particular wind direction. The foundation plate can be rotated through 360°.

60 In order to be able to exploit wind from both the starboard and the port directions relative to the ship's course the profile of the sail surface is made absolutely symmetrical and the direction of rotation of the drive for the rotor is made reversible. In order to be able to exploit winds from different directions relative to the ship's course the rotor together with its drive and the associated sail can alternatively be mounted on a common base plate which is rotatably arranged on a column or a similar type of substructure.

65 For this purpose a rotational joint (for example a roller bearing) is incorporated between the common base plate and the substructure. An electric or hydraulically actuated positioning device which is automatically controlled by a wind direction measuring system rotates the common base plate with the wind drive to the correct pitch angle appropriate to the particular wind direction.

70 In order to be able to set the wind drive out of operation at any time the rotor is brought to a standstill by stopping its drive member. The sail is then rotated about its central longitudinal axis until one of the two entry edges has reached its position of smallest separation from the rotor jacket. The foundation

plate with the sail mounted thereon is then turned until the sail surface is located in the lee of the stationary rotor (see fig. 2c).

A few embodiments of the invention are illustrated:

Fig. 1 shows a perspective view of the invention,

Figs. 2a-2c show schematic illustrations with different wind flow directions,

Fig. 3 shows a view similar to that of Fig. 1 but with a common base plate for the rotor and sail, with the base plate being rotatable about its own axis, and

Fig. 4 shows a view similar to that of Fig. 1 but with a sail of sail cloth.

A wind drive or wind auxiliary drive for ships in accordance with Fig. 1 consists of a rotor 1 with end discs 11, 12 which generates propulsion when blown on by a wind and when set in rotation. The direction of rotation of the rotor can be selectively controlled in correspondence with the wind direction. The bearings and drive for the rotor 1 are located in the rotor carrier 14 which is fixedly connected with the ship's structure, which is not shown in any further detail.

A foundation plate 15 is mounted on the rotor carrier 14 by means of a rotational joint 13 and can be swivelled 7/8 through 360° about the longitudinal axis 2 of the rotor. The swivel drive is housed in the rotor carrier 14. A sail 3 of aerofoil shape which likewise generates propulsion when blown on by the wind is mounted on the foundation plate 15. A rotational joint 16 which makes it possible to rotate the sail 3 through 360° about its pitch axis 4 is located in the sail support mast. The rotational movement 9/10 of the sail can be selected clockwise or counterclockwise with the aid of a turning motor which is integrated in the rotational joint 16 in the sail support mast.

Figs. 2a and 2b schematically illustrate a ship 20, and also the position of the sail 3 and the direction of rotation of the rotor 1, with the wind blowing from the starboard direction 17 and from the port direction 18.

Furthermore Fig. 2c shows the wind drive set out of operation when the wind flow is from the front 19. In this condition the rotor 1 is brought to a standstill and the sail is positioned in the longitudinal direction of the ship in the lee of the rotor.

Fig. 3 shows a rotor 1 rotating about its axis 2 and a sail 3 which is rotatable about its pitch axis 4, with the rotor 1 and the sail 3 being mounted on a common base plate 21 which is in turn swivellable about the axis 22.

Fig. 4 corresponds to Fig. 1 the only difference being that a non-rigid sail 23 of sail cloth is provided on a Rah-mast 24 in place of the rigid sail 3.

## CLAIMS

1. A wind drive for ships comprising a Flettner-rotor and a surface which is influenced by the flow conditions at the periphery of the rotor, is swivellable about the rotor axis and is rotatable about a pitch axis of its own, characterised in that the surface is formed by a sail (3) which is symmetrical about its pitch axis (4) and rotatable through 360° about the pitch axis (4), with the sail also being acted on, in part, by the undisturbed wind flow.

2. A wind drive in accordance with claim 1 and

characterised in that the direction or rotation (5/6) of the rotor (1) can be reversed in manner known per se and in that the rotor can be stopped.

3. A wind drive in accordance with claims 1 or 2 and characterised in that the rotor (1) is provided with end discs (11/12) in manner known per se, and in that the sail (3) fits between these end discs.

4. A wind drive in accordance with one of the claims 1 to 3 and characterised in that the rotor (1) and the sail (3) are arranged on a common base plate (21) which is rotatable through 360° and about a swivel axis (22) disposed parallel to and between the pitch axis (4) and the rotor axis (2).

5. A wind drive in accordance with one of the claims 1 to 4 and characterised in that the symmetrical sail is either rigid or a symmetrically constructed sail (23) of known construction, e.g. of sail cloth.

6. A wind drive or auxiliary wind drive for ships, or other boats, substantially as herein described and as illustrated in the accompanying drawings.

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